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I am Stephen Brandt, Director of the Great Lakes Environmental Research Laboratory (GLERL), a research component of the National Oceanic and Atmospheric Administration (NOAA) of the Department of Commerce. I appreciate the opportunity to provide information about NOAA's current invasive species research priorities, GLERL's role in invasive species research, no ballast on board (NOBOB) vessels, the status of ballast water treatment technology, and Federal coordination and cooperation. I currently co-chair the Council of Great Lakes Research Managers of the International Joint Commission. In addition, I serve as NOAA's regional representative on the Great Lakes Interagency Collaboration Working Group. Our lab also houses NOAA's National Center for Research on Aquatic Invasive Species.

Invasive Species and the Great Lakes

The poster child for aquatic invasions—the zebra mussel—was first discovered in Lake St. Clair in 1988. The introduction of zebra mussels provided the initial impetus for coordinated Federal action on aquatic nuisance species and led directly to the passage of the Nonindigenous Aquatic Nuisance Prevention and Control Act of 1990 (NANPCA). Those of us in the Great Lakes region, however, are acutely aware of the fact that the invasive species problem is not a single species problem. Over 180 nonindigenous aquatic species have become established in the Great Lakes. Many of these species have only had minimal impacts on Great Lakes resources, but a few have profoundly changed Great Lakes ecosystems and been very costly. Probably only a few of us remember when lake trout were a major recreational and a significant commercial fishery before sea lampreys began to plague the upper Great Lakes. We are still living with the consequences of that introduction. The Great Lakes Fishery Commission estimates that sea lamprey control expenditures have totaled $250 million, and we continue to spend $12-15 million per year for control activities. More of us certainly remember when die-offs of introduced alewives fouled our beaches before an adaptive management program was introduced. Some of us have had direct experience with spiny and fishhook water fleas fouling our fishing gear. A few years ago, the State of Ohio had to shut down its smallmouth bass fishery during the peak season for recreational anglers in the western portion of Lake Erie because of predation on unguarded nests by the round goby. The newest Great Lakes invader is the bloody red shrimp (*Hemimysis anomala*) first reported in Lake Michigan by NOAA GLERL in November, 2006. The extent and impact of this invasion is currently being assessed.

The Great Lakes basin is the aquatic gateway to the heartland of America and a hot spot for aquatic species introductions to major interior sections of the United States. While the spread of aquatic species introduced in most U.S. coastal ecosystems is generally restricted to adjacent contiguous coastal ecosystems, the Great Lakes provide a pathway for freshwater-adapted invasive species to spread throughout the interior waters of the central and eastern United States. One need only examine the spread of the zebra mussel and the quagga mussels to understand this. Quagga mussels were recently found west of the Continental Divide in lakes Mohave and Havasu in Arizona, and Lake Mead in Nevada. In the Great Lakes quagga mussels are replacing zebra mussels throughout the basin. The quagga mussels occupy a greater depth range and are not restricted to hard substrates because of its shell morphology. Zebra mussels are now outside the Great Lakes–St. Lawrence River system as far west as eastern Arkansas, as far south as the Mississippi delta below New Orleans, Louisiana, and east as far as the Hudson River estuary north of New York City. Zebra mussels have fouled industrial and municipal water intakes, which must now be chemically treated on a regular basis throughout the summer months to keep them flowing. Quagga mussels are expected to continue to cause these same problems. Estimates of the annual cost of zebra mussel control and mitigation are in the $100's of million per year in the Great Lakes basin alone.

Just as disturbing as the total numbers of introduced species is the fact that the number of introductions has not decreased significantly. Some believed that by requiring vessels arriving from outside the U.S. EEZ to exchange ballast water prior to entering the Great Lakes, this trend would be reversed. But we have seen introductions continue, and this has drawn attention to the issue of ships with no ballast on board (NOBOB). The majority of ships that enter the St. Lawrence Seaway technically are carrying no ballast, but may have residual water and sediment that can be resuspended and discharged in their passage through the Great Lakes. When we realized that NOBOB ships could be a source for new introductions, NOAA's GLERL began a research program to investigate this pathway, which was completed in 2005. In the past year NOAA has teamed with the Smithsonian Environmental Research Center to prepare an assessment of the effectiveness of ballast water exchange. A draft of the report has also recently been completed and is presently being reviewed for clearance prior to being delivered to Congress.

Research Priorities for Invasive Species

Research is critically needed to improve the scientific basis for our decision-making. I would like to focus on several current areas of research, including ballast water exchange, technology, vessels declaring 'no ballast on board' or NOBOB's, patterns of invasion, and impacts.

Ballast Water Exchange Research

Only a few studies have examined the effectiveness of open-ocean ballast water exchange (BWE), the only ballast water management practice currently approved by the United States. Existing studies have been restricted to a few vessel types and only assessed the effect of exchange for a few organisms. The lack of detailed assessments concerning the mechanics and effectiveness of ballast water exchange represents a fundamental gap in determining the value of exchange, compared with alternative strategies to prevent future invasions. Recently one of our research partners, Smithsonian Environmental Research Center (SERC), conducted over two dozen on-board BWE experiments on various types of cargo vessels, three of which were in conjunction with the Great Lakes NOBOB Assessment Program lead by GLERL. They found that ballast water exchange is highly effective (80-95% reduction in coastal organisms) at reducing the risk of coastal species transfers when conducted according to regulations and guidelines, but it is not 100% effective and some coastal organisms remain.

For the Great Lakes, the protective effects of exchange may be greater than for other coastal regions. The concentration of organisms in open-ocean water is much lower than in coastal areas where ships are likely to have taken on their original ballast water. For ships bound to marine U.S. coastal waters, the effect of ballast water exchange is primarily flushing of coastal organisms out of the tank and replacement with mid-ocean organisms. This ballast water exchange results in a reduction in the concentration of organisms that are likely to establish new populations in coastal ecosystems. For ships bound for the Great Lakes, the largest freshwater system in the world, exchange with open-ocean water plays two prevention/protection roles: (1) exchange reduces the number of coastal organisms present in the ballast water through flushing and dilution and (2) exchange may also kill many organisms from foreign fresh or low-salinity brackish coastal areas that are adapted to freshwater and thus are not tolerant of rapid changes or prolonged exposure (days) to salinity at open-ocean levels (greater than 30 ppt). SERC and NOAA have been conducting salinity tolerance experiments and last year added experiments on the use of high-concentration sodium chloride brines as a preventive treatment in NOBOB ballast tanks. I'll elaborate more on this later.

Based on experimental data, vessel traffic and invasion history analyses, it appears that BWE has likely dramatically reduced the supply of coastal organisms being discharged with foreign-originating ballast water into the Great Lakes and Chesapeake Bay. In the absence of proven alternative methods to reduce species transfers, these results suggest that BWE should be considered a useful and beneficial ballast management practice until better methods are widely available.

Technology Development Research

Ballast tanks are, by far, the most significant means by which aquatic species are being moved around the globe. Research and technology development are the keys to workable and effective methods to reduce invasive species introductions from ballast water and tanks. However, the problem is complex. The architecture of ballast tanks differs from vessel to vessel. Many ballast tanks are partitioned into relatively small compartments, like a honeycomb, with interconnecting holes for water movement. Most ballast tanks are not designed for easy access and most are crisscrossed with ribbing for structural support that can disrupt the flushing of material from the tank, or the mixing of a biocide throughout the tank. Some tanks have a low, flat profile, while others are cavernous. Reliable and affordable technology for effective treatment of ballast water, either before it enters a ship or while in the ballast tanks, is still in development. Several alternative ballast water treatment technologies are in varying stages of testing. The two most common approaches being worked on include physical removal of organisms or treatment to kill them. In addition, methodologies for dealing with pathogens and parasites as well as affirmation that treatment technologies are effective against them are needed.

NOBOB Research

Although circumstances vary from ship to ship, some water and entrained sediment usually remains in ballast tanks even after complete pump-out. The residual water and sediment can contain a wide assortment of plants, animals, and microorganisms, including so-called "resting stages" such as cysts or resting eggs. The life cycles of many invertebrates, algae (including toxic dinoflagellates), protozoan, and bacterial species include the capability of producing resting stages. Production of resting stages ensures long-term viability of the population because they are extremely resistant to adverse conditions including anoxia, noxious chemicals, freezing, and passage through digestive tracts of fish and waterfowl. Resting eggs of invertebrates and cysts of dinoflagellates usually sink when released. Resting stages may remain viable in sediments for decades or even centuries, and can germinate or come to life under a combination of favorable light, temperature, and other environmental conditions. We are particularly concerned about residual sediments in ballast tanks in the Great Lakes region, where over 90% of the foreign vessels entering declare NOBOB. Consider a tank holding 1500 metric tons of water when full. If only 0.5% of that volume is unpumpable, then up to 7.5 metric tons (7.5 cubic meters, or about 2,000 gallons) of water would remain. Across a ship's numerous tanks, a significant volume of ballast water and mud can remain on board. As ballast water treatment technologies are developed and tested, their effectiveness in dealing with the NOBOB residuals should also be evaluated.

The effects of different management practices on reducing the biological invasion risk associated with NOBOB tanks is a critical area for research. Use of best management practices may enhance the effectiveness of new treatments by reducing the amount of mud present during treatment. As part of this effort, research is needed to develop remote measurement capabilities that allow better measurements of the amount of sediment accumulated across the entire ballast tank.

Patterns, Corridors, and Vectors of Invasion

Preventing the movement of non-native organisms from one location to another is the only effective strategy to prevent invasions. A major barrier to planning for and preempting future invasions is trying to identify where future species invasions may originate and which species may pose the highest potential risk of successfully invading that ecosystem. Comprehensive analyses of recent and past patterns of species invasions by coastline, region, or coastal ecosystem may help to identify the most significant invasion corridors or pathways by which invasive species are brought to our coastal ecosystems. Monitoring and analysis of global trade patterns may be able to help identify future shifts in likely invasion corridors leading to the United States. These analyses may help determine which species are capable of invading U.S. coastal ecosystems.

Minimizing the Ecosystem and Economic Impacts of Invaders

Once a species has become established in an ecosystem, the ecosystem by definition has changed and the species is nearly impossible to eradicate. Unlike many chemical contaminants that dissipate through time, invasive species do not have a ‘half-life' and are likely here to stay. While we can try to contain the species, it is a very difficult task to accomplish, as illustrated by the quagga mussel expansion west of the Continental Divide. Management needs to adapt to the presence of an invasive species, and the sooner that adaptation can be made, the greater the chance is to minimize the species impact.

Research is necessary to make this adaptation. Monitoring and long-term assessment, targeted to the regional level and integrated at the national level, are essential components of this type of research. Many of the present management approaches in the Great Lakes are based on studies and models that were developed before the major incursions of invasive species in the 1980s. The zebra mussel has had perhaps the most profound effect on the Great Lakes ecosystem, second only to human beings. Studies to modify existing ecosystem management models or develop new models that accurately account for the food web and energy flow changes caused by invasive species are critically needed.

GLERL's Role and Activities in Aquatic Invasive Species Research

GLERL is headquartered in Ann Arbor, Michigan, and has been in existence for over 30 years. GLERL has been actively engaged in research on aquatic invasive species since shortly after zebra mussels were initially discovered in Lake St. Clair in 1988. Our mission is to conduct high-quality research and provide scientific leadership on important issues in both the Great Lakes and marine coastal environments, leading to new knowledge, tools, approaches, and awareness.

GLERL achieves its mission through applied research, monitoring, technology development, information synthesis and assessment, multi-institutional partnerships, scientific leadership and education. GLERL houses a unique combination of scientific expertise in biogeochemical, hydrological, ecological, physical limnology, fish ecology, and oceanographic sciences. This broad range of disciplines is needed to adequately understand and address the important and complex issues that confront the effective management of aquatic environments. GLERL's research is focused on developing high-level capabilities in ecosystem forecasting currently organized into four broad research themes: Ecological Prediction, Aquatic Invasive Species, Physical Environment Prediction, and Environmental Observing Systems. GLERL works to determine and forecast how ecosystems are changing, the nature and causes of those changes, and the impacts of those changes.

GLERL has a strong history and fundamental belief in collaboration and partnerships. GLERL has a formal Cooperative Institute with the University of Michigan (The Cooperative Institute for Limnology and Ecosystems Research) that provides a direct bridge between GLERL and academic institutions throughout the Great Lakes basin.

Overall, GLERL's research is coordinated with a number of agencies, institutions, and the user community at a number of levels and in a number of ways. For example, research scientists collaborate routinely in order to take advantage of each other's expertise and avoid duplication of effort. Other coordinating efforts occur through policy committees, the International Joint Commission (IJC) Council of Great Lakes Research Managers, scientific meetings and workshops. GLERL houses the headquarters of the International Association for Great Lakes Research. Current active collaborations of GLERL scientists include 240 scientists representing approximately 150 institutions spread across 27 states, 5 provinces of Canada, and 14 foreign countries. These institutions include 19 federal agencies, 50 universities, and 25 other entities, which include U.S. and foreign private institutions and state and local institutions. GLERL scientists serve on a number of scientific and advisory committees such as the IJC Council of Great Lakes Research Managers, the technical Science Advisory Board of the Great Lakes Fishery Commission, and the Binational Climate Committee. Two Sea Grant extension agents have been placed at GLERL with the responsibility to provide a two-way linkage with the Great Lakes coastal community via the existing network of nearly 70 Sea Grant extension agents in the region and with the Great Lakes Human Health Network. The goal is to ensure that GLERL's research gets to those who can use it and also to make sure that user needs are being met by GLERL's research. GLERL scientists thus play a critical role in academic, state, federal, and international partnerships, provide information to support decisions that affect the environment, recreation, public health and safety, and the economy of the Great Lakes and coastal marine environments.

GLERL is NOAA's leading institution for aquatic invasive species research and has a legislative mandate to conduct such research. All of GLERL's research on invasive species falls within the priorities set by the Aquatic Nuisance Species (ANS) Task Force and builds directly on the National Management Plan. GLERL represents NOAA on the Great Lakes Regional Panel of the ANS Task Force and has actively served on that panel since its inception. GLERL scientists have also served on various committees of the National Invasive Species Council to help develop the National Invasive Species Management Plan and work in direct collaboration with other agencies on these activities including the U.S. Coast Guard and Environmental Protection Agency. GLERL has also taken the lead to develop a 5-year strategic plan for invasive species research

The primary purpose of GLERL's invasive species research is to expand our knowledge of invasive pathways and the biology and ecological impacts of nonindigenous species in the Great Lakes. Research on pathways has focused on the ballast water vector and GLERL has NOAA’s only in-house ballast-related field and laboratory programs. Our impact research involves field investigations on Lake Michigan, Saginaw Bay, Lake Huron, and other sites to measure ecosystem changes and community responses to invading species, and to examine the ecology of the organisms themselves. Research also includes laboratory experiments to examine the biology (feeding, development, physiology) and ecological interactions of the invading organisms, including study of how these organisms absorb, metabolize, and eliminate or accumulate toxins. The program historically focused on the zebra mussel, but has recently expanded to address impact of other aquatic invasive species.

The NOAA National Center for Research on Aquatic Invasive Species is based at GLERL and works with the NOAA Invasive Species Program to ensure that NOAA invasive species research is coordinated across regions. GLERL maintains a Great Lakes Aquatic Nonindigenous Species Database and uses network analysis to model and quantify the impact of exotic invertebrate invaders on food web structure and function. Of particular relevance to ballast water management, GLERL completed research on the effectiveness of certain biocide treatments, such as chemicals, heat, UV light and oxygen deprivation, on the viability of resting eggs, which are often found in NOBOB vessel sediments. GLERL is also working with a private company and the U.S. Naval Surface Warfare Center to use computational fluid dynamics modeling of ballast tank flow to improve understanding and maximize the effectiveness of ballast water exchange in removing coastal water.

No Ballast on Board (NOBOB)

As I mentioned earlier, NOAA, through GLERL, is conducting research on NOBOBs and how to prevent species invasions from the residual water and sediments on board these vessels. In 2005 NOAA completed a three-year multi-institutional research program to characterize the biota found in NOBOB vessels entering the Great Lakes and to evaluate the effectiveness of at-sea ballast water exchange. The residual water and sediment remaining in these NOBOB vessels can contain a wide assortment of live plants, animals, and microorganisms.

On average about 90 percent of the saltwater ships entering the Great Lakes are NOBOB vessels and are not required to conduct exchange under the ballast water management regulations implemented in 1993 by the U.S. Coast Guard.

NOBOB ships are loaded to capacity with cargo and carry no pumpable ballast water on board. However, water taken on as ballast by a NOBOB vessel in a U.S. port to maintain trim and stability during operations between ports can mix with residual ballast water, sediment, and any associated invasive organisms, and later be discharged into U.S. waters as the vessel moves between a succession of ports. Thus, ballast-water operations of NOBOB vessels present a risk of invasion; the magnitude of such risk is unclear.

A multidisciplinary NOBOB Assessment Program was designed to conduct research to directly assess the potential invasion threat represented by overseas vessels operating in the Great Lakes. The primary objectives of the research were to characterize the biota in ballast tank residues and evaluate efficacy of mid-ocean exchange in removing coastal organisms from low salinity ballast. All results are reported in an extensive report "Assessment of Transoceanic NOBOB vessels and Low-Salinity Ballast Water as vectors for Non-indigenous Species Introductions to the Great Lakes."

The research team surveyed 103 NOBOB vessel crews about their management practices and boarded 42 of those vessels to enter and sample residual water and sediment in 82 ballast tanks. Total ballast residuals (water and/or sediment) ranged from negligible to

200 metric tons with an average water residual of 44 tons and average sediment residual of 20 tons. The study also found that ships were making a considerable effort to minimize sediment, as approximately 60% of those sampled had less than 10 metric tons of sediment. Moreover, the results indicated that ships' crew were generally aware of invasive species issues.

A diverse group of live phytoplankton (small, floating plant life) and invertebrate biota (eggs, larvae) were found in the residuals, including dozens of non-indigenous species not yet reported in the Great Lakes. While microbial pathogens were detected in about half the ballast tanks sampled, further assessment is needed to determine if these pathogens pose a human health risk. The study also found evidence that saltwater flushing will decrease the number and diversity of live organisms in NOBOB residuals, and would also expose the organisms to salinity shock, just as in ballast water exchange. This study provided the scientific basis for the U.S. Coast Guard to issue a new policy in 2005 asking NOBOB vessels entering the Great Lakes to take steps as appropriate to increase the salinity of their residual ballast water to greater than 30 ppt by saltwater flushing, if not by ballast water exchange. It was also part of the basis on which Canada began enforcing new regulations in 2006 that require all water in ballast tanks of ships arriving from overseas, including the residual water in NOBOBs, to have a salinity greater than 30 ppt, achieved by ballast water exchange or saltwater flushing, in order for those ships to discharge their ballast water in the Great Lakes.

Other general conclusions were:

- The microbial, phytoplankton and invertebrate data and evaluations developed during this study confirm that NOBOB vessels are a vector for non-indigenous species introductions to the Great Lakes basin, potentially for algal and invertebrate biota.
- Risk of introduction via egg/spore hatching from sediment is very low compared to risk associated with organisms in residual water. Residual water comprises approximately 69% of ballast residuals and invertebrates and phytoplankton in residual water probably have the greatest opportunity for expulsion from ballast tanks.
- Invertebrates and phytoplankton were lower (particularly freshwater species) in ballast tanks that had been flushed or exchanged, resulting in saline residuals.
- All biota generally decline during transport in proportion to duration.
- Several non-indigenous species were detected in Great Lakes water loaded as ballast and could be spread to the upper Great Lakes.
- Ballast water exchange is imperfect, but is the only management practice now available in the absence of more effective and consistent management tools.
- The risk of NOBOB-related invasive species introductions can be lowered with diligent application of good management practices, but maximum protection will need new highly effective methods to treat ballast water and residuals to required biological end points.
- Estuarine species were found to have a variable tolerance to salinity shock and some are able to survive prolonged exposure to higher salinities.
- NOBOB vessels entering the Great Lakes with fresh or low-salinity residuals represent the greatest threat for aquatic invasive species introductions.

- There was no evidence that NOBOB residuals are a significant threat to human health, but it is prudent to consider all ships as potential carriers of pathogens.

GLERL has also conducted research on disinfection of ballast water and residual sediments with chemical disinfectants. The research found that in general, chemical treatment of residual sediment in ballast tanks for the purpose of killing aquatic invertebrates and their resting stages may not be effective because sediments and organic detritus react with some biocides (such as gluteraldehyde and hypochlorite), and burial in sediment can protect organisms, eggs, and spores from exposure to chemical biocides, including seawater. Heat was found to be highly effective, but the required temperatures and exposure times could be very costly. These methods, however, would still reduce the risk (not eliminate it) from ballast residuals and may also be useful in the overall treatment of ballast water when coupled with other methods.

GLERL is just completing a two year study of Ballast Water Best Management Practices (NOBOB-B: Best Management Practices). We have found that application of BMPs by cargo ships is very dependent on local conditions — weather, working rules of the dock (24/7 vs. daylight), season (rainy vs. dry), river berth vs. sheltered harbor or deep water harbor. Further, the information needed to support some practices — such as not ballasting where algal blooms are “known to occur in high abundance” — is simply not routinely available. Acceptance and implementation of best management practices by the shipping industry must be understood as a commitment to make a “good faith” effort to do better than would be case without BMPs. We concluded that implementation of BMPs to protect the Great Lakes, while better than no effort at all, is not likely to more than marginally lower overall risk.

Of greater significance is the efficacy of salinity shock on organisms that might be expected to successfully establish in the Great Lakes. To this end the Smithsonian Environmental Research Center, as part of the NOAA NOBOB-B Program, is conducting laboratory experiments on the effects of BWE-related salinity shock on a variety of invertebrate organisms from the estuarine areas of the Baltic Sea, Chesapeake Bay, San Francisco Bay, and the Great Lakes (the latter in collaboration with NOAA’s GLERL). Their experiments clearly show that many invertebrate taxa that originate from low-salinity ports can be eradicated from ballast tanks relatively quickly through exposure to full-strength seawater. This was especially true for the invertebrate animals they tested from freshwater or oligohaline habitats (0-2 ppt), while animals from habitats with higher average salinities (2-5 and 5-10 ppt) exhibited greater resistance to treatments of full-strength seawater. Invertebrates identified as salinity-tolerant species by their experiments include estuarine animals that often experience dramatic fluctuations in salinity and temperature as part of their normal life histories and these factors have contributed to their ability to invade estuarine habitats. However, only a subset of salinity-tolerant species is also capable of surviving and reproducing in a constant freshwater habitat such as the Great Lakes. With regard to ballast water exchange methods, the greater risk for the Great Lakes lies with species or particular life stages that can tolerate full-strength seawater for at least two days and also establish viable populations within a constant freshwater system.

In a related study funded by NOAA and being performed jointly by NOAA and SERC, high-concentration sodium chloride brines are being evaluated as a possible tool for treatment of NOBOB ballast tanks that have not been exchanged or flushed with sea water due to operational or safety constraints. This study (NOBOB-S) is on-going, but results so far are promising that short-term (in the range of 2-6 hours) exposure to concentrated sodium chloride brines (30-60 ppt) can be an effective alternative to longer-term exposure to full-strength seawater when the latter is not possible, and may also be more effective against animals that are tolerant of full-strength sea water. However, additional considerations that must be evaluated include cost, availability, and effect on corrosion of ballast tank structural material and how brines can be introduced into ballast tanks. A parallel study is underway in Canada to assess these factors.

This is a complex problem that requires the cooperation of regulatory agencies, the scientific community, the shipping industry, and the public to identify the best solutions. These studies will provide a more comprehensive scientific basis for considering new policies and identifying possible preventive measures and treatments.

Status of Ballast Water Treatment Technology

When NANPCA was passed in 1990, Congress recognized that there was a larger issue than the problems being caused by zebra mussels. Recognizing that the pathway that brought the zebra mussel to the United States could be a pathway for other species, the law required that steps be taken to manage ballast water. By the time that NANPCA was due for reauthorization, it was common knowledge that ballast water currently was and continues to be the most significant pathway for new introductions into coastal waters.

The passage of the National Invasive Species Act in 1996 expanded the ballast water provisions contained in NANPCA. The U.S. Coast Guard was charged with setting up voluntary guidelines for ballast water management and monitoring the effectiveness of the voluntary guidelines. After a finding that the voluntary guidelines were not effective, the U.S. Coast Guard issued regulations making ballast water management mandatory, with certain exceptions, for all commercial vessels entering U.S. ports from outside the Exclusive Economic Zone. These regulations became effective September 27, 2004.

When the NANPCA was passed in 1990, virtually the only option available for ballast water management was ballast water exchange. Because the mandatory provisions applied to the Great Lakes, it was assumed that the risk of new introductions would be substantially reduced. However, it became increasingly obvious that mid-ocean exchange should be only an interim solution to the broader problem. First, exchange has associated safety issues. Second, the effectiveness of ballast water exchange was difficult to establish, but is clearly not 100%. By the time of the reauthorization of NANPCA in 1996, there was widespread agreement that the ultimate solution would be in the development of treatment technologies. In 1996, the National Research Council of the National Academy of Sciences published a report containing an evaluation of potential treatment technologies.

During the reauthorization in 1996, the Congress set up a competitive grants program for the development of new ballast water management technologies, the Ballast Water Management Demonstration Program. The program, administered by the U.S. Fish and Wildlife Service (FWS) , U.S. Maritime Administration and NOAA, competitively funds ballast water projects evaluated by an independent panel of scientists, engineers and users from the public and private sectors.

Initially, most of the projects were smaller scale and involved proof of treatment concepts. The program has progressed to larger scale testing of specific treatment technologies, as well as technologies necessary for real world application, for example monitoring systems. Research has been sponsored on a wide range of technologies including filtration, thermal treatment, ultra violet radiation, biocides, acoustic bombardment, ozone injection, and nitrogen injection. Through FY 2006, NOAA and FWS have funded 65 projects through the Ballast Water Management Demonstration Program. In addition, NOAA's Sea Grant program has funded an additional 27 ballast related projects through its aquatic nuisance species competition.

In 2006, NOAA's Ballast Water Technology Demonstration Program awarded a $1.25 grant to support the Great Ships Initiative, a plan to develop and implement effective ballast water treatment technologies for use in the Great Lakes. In this effort NOAA is working with more than a dozen major U.S. and Canadian Great Lakes ports, the Northeast Midwest Institute, the National Fish and Wildlife Foundation, the University of Wisconsin, the U.S. Maritime Administration and others. The $3.5-million Great Ships Initiative sets up the infrastructure to identify the most promising technologies and provide objective testing and developmental support to turn these technologies into usable systems.

I am pleased to report that several technologies are showing promise. Several systems have been presented to the Marine Environmental Protection Committee of the IMO, and there are a very small number of ballast water treatment systems currently in use on ships actively engaged in maritime commerce. None of these technologies have yet unequivocally demonstrated the ability to meet discharge standards under all operational conditions, and none currently are in wide use, but progress toward these ends seems straightforward.

To demonstrate our optimism that technologies should be available in the near future, I would note that in a recent submission to the Marine Environment Protection Committee of the IMO, the United States expressed its judgment that treatment technologies would be available by the initial date for installment on new ships—January 1, 2009. Both Germany and Norway submitted similar judgments.

Federal Coordination and Cooperation

The efforts of the Federal government on ballast water issues have demonstrated how coordination can improve our effectiveness. Much of this activity has been fostered by the interagency Aquatic Nuisance Species Task Force set up under NANPCA. The Task Force is chaired by NOAA and FWS and has seven other federal members and thirteen ex officio members representing other levels of government. In addition, two invited observers from Canada's Federal Government participate. This pattern is repeated with even stronger state government and other stakeholder involvement on each of the Task Force's six Regional Panels.

Similar coordination is occurring at a regional level here in the Great Lakes. As an example, when a snakehead fish was discovered near Chicago, alarm bells went off. The Regional Working Group, representing 11 federal agencies, was established by Presidential Executive Order in May 2004. We developed a rapid response and coordinated sampling program that, within days, confirmed that this was an isolated case. Although it proved to be an isolated occurrence, it highlighted the need to have procedures in place for future incidents. A Rapid Response Invasives Subcommittee has been established by the RWG. The Federal Aquatic Invasive Species Rapid Response Subcommittee ("FAISRR" Subcommittee) is charged with advising on and strategically advancing implementation of federal roles and responsibilities in detecting new aquatic invasive species in the Great Lakes and mobilizing resources in a rapid response effort. Subcommittee's initial focus will be to develop and document a federal agency network and develop proposed rapid response operation procedures that will provide clear channels of communication and rapid mobilization of federal resources in the event a rapid response to a new Great Lakes invader is needed. The network will serve as the primary point (s) of contact for responding to requests for assistance, whether they come from federal, state, or local authorities. The committee has established lists of Agency Points of Contacts and Technical Contacts (which is the basis for the Network) and is working with the ANS Task Force on a List of Taxonomic Experts.

The Aquatic Nuisance Species Task Force is not the only entity working on such coordination. Executive Order 13112 created a National Invasive Species Council (NISC) to help coordinate invasive species actions more broadly. NISC currently has representatives from thirteen federal departments and agencies. While the Aquatic Nuisance Species Task Force is involved with implementation of species activities, NISC is a policy and coordinating body. In order to give structure to the federal government's efforts in addressing invasive species issues, NISC prepared a comprehensive National Management Plan. On a regional level, invasive species are a key element in the Great Lakes Regional Collaboration. Similarly, a number of executive agencies are working together on the Security and Prosperity Partnership that was set up with Mexico and Canada. Invasive species were explicitly mentioned in the agreement, and ballast water has been identified as an area of cooperation.

Ballast water research is an excellent example to show how collaboration and cooperation work. From a NOAA perspective, it is not an exaggeration to state that we often are in contact with other federal agencies on ballast water issues several times a week. Regular meetings take place among the federal partners to address specific aspects of the ballast water issue. Our federal partners include FWS, the U.S. Coast Guard, the Environmental

Protection Agency, the Maritime Administration, the U.S. Geological Survey, and the Department of Defense.

I previously mentioned joint management of the Ballast Water Management Demonstration Program. To demonstrate how we intend to continue and expand coordination, NOAA will give preference in the future to any technology found promising enough to be included in the Coast Guard's Shipboard Technology Evaluation Program (STEP). The STEP program is set up to test promising new technologies under operational conditions. Participants in the program will be exempt from current requirements for ballast water exchange. In return, they must adhere to a testing/sampling protocol and report results. The Coast Guard has indicated that participants will be individual ships rather than exemptions for a whole fleet.

The NOBOB investigation is also a good example of a collaborative effort. Funding was provided by NOAA, the Great Lakes Protection Fund, the U.S. Coast Guard and the Environmental Protection Agency. The study involved investigators from GLERL, the University of Windsor, the University of Michigan, the Smithsonian Environmental Research Center, Old Dominion University and Phillip T. Jenkins and Associates. Overall, this research would not have been possible without the cooperation and assistance of the shipping community especially, FedNav, Polsteam a number of ship operators/owners.

As agencies have worked together on specific issues, the number of informal contacts has increased. In part, this is because personnel in one agency become more familiar with the individuals and resources in another agency. As an example, if the U.S. Coast Guard has a biological question, it does not hesitate to contact NOAA. Ultimately, such informal contacts can save time and money.

Conclusions

We only have to look at the spread of zebra and quagga mussels and the continuing effort to manage the sea lamprey to realize that we will be living with the consequences of past introductions. However, we have made progress towards reducing the risks associated with the most significant pathway for introductions into coastal areas—ballast water. With the addition of NOBOBs to the regulatory measures already in place, we expect to see a reduction over time in the number of new introductions from overseas related to ballast water discharges. We are optimistic that ongoing research will lead to a number of promising technologies in the near future. In many ways, the progress is the result of a virtually unprecedented degree of cooperation by a number of different federal agencies, universities and the private sector. This cooperation has involved advance planning as well as sharing expertise and resources.

This concludes my written statement. I would be happy to respond to any questions that you may have.